



**Missouri Department of Transportation**

**Bridge Division**

**Bridge Design Manual**

**Section 3.74**

**Revised 02/18/2004**

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SECTION 3  
3.74 PILING

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**PILE CAPACITIES  
SEISMIC PERFORMANCE CATEGORY A**

**Design**

**Design Bearing**

Design Bearing is the actual computed load on a pile due to all Dead and Live Loads and other applicable forces which may act on the structure. This load shall be that produced by using the minimum number of piles which give loads not exceeding the maximum capacities; or that number of piles required by spacing considerations, minimum number of piles in a group, ect.

**Friction Pile**

The Design Bearing for friction pile used in piles tables on plans shall not fall below the minimum (\*) or exceed the maximum capacities shown in the Pile Capacities Table (\*\*). The load on a friction pile may be less than the minimum capacity shown, but tension on a pile will not be permitted.

(\*) If the Design Bearing for friction piles falls below the minimum, show the minimum value (shown below) on the Front Sheet of plans.

(\*\*) Unless a higher load is indicated on the Design Layout Sheet. Higher values for friction piles may be established by load tests.

**Point Bearing Pile**

The Design Bearing for point bearing piles which are to be driven to rock or other point bearing material shall be designed for 9,000 psi, unless the Design Layout specifies otherwise. See the Piles Capacities Table.

**Pile Capacity**

POINT BEARING PILE CAPACITIES				
Type (Steel)	A <sub>req</sub> (In. <sup>2</sup> )	Point Bearing		
		6,000 psi	9,000 psi	12,000 psi
HP10 x 42	12.35	37 Ton	56 Ton	74 Ton
HP12 x 53	15.58	47 Ton	70 Ton	94 Ton
HP14 x 73	21.46	65 Ton	97 Ton	129 Ton

FRICTION PILE CAPACITIES			
Type	Max. Capacity	Min. Capacity	Standard
CIP Conc. Pile (14")	30 Ton	20 Ton	MO Std. Plans Drawing 702.02
CIP Conc. Pile (20")	40 Ton	20 Ton	
CIP Conc. Pile (24")	48 Ton	30 Ton	

**PILE CAPACITIES**

**Design**

**SEISMIC PERFORMANCE CATEGORY B, C & D**

**Design Bearing**

Design Bearing is the actual computed load on a pile due to all Dead and Live Loads and other applicable forces which may act on the structure. This load shall be that produced by using the minimum number of piles which give loads not exceeding the maximum capacities; or that number of piles required by spacing considerations, minimum number of piles in a group, etc.

**Friction Pile**

The Design Bearing for friction pile used in piles tables on plans shall not fall below the minimum (\*) or exceed the maximum capacities shown in the Pile Capacities Table (\*\*). The load on a friction pile may be less than the minimum capacity shown, but tension on a pile will not be permitted for AASHTO Group I thru VI loads. For Earthquake Loads only the minimum load on a pile shall be the allowable uplift force specified for piles in Bridge Manual Section 3.71 under Seal Course Design.

(\*) If the Design Bearing for friction piles falls below the minimum, show the minimum value (shown below) on the Front Sheet of plans.

(\*\*) Unless a higher load is indicated on the Design Layout Sheet. Higher values for friction piles may be established by load tests.

**Point Bearing Pile**

The Design Bearing for point bearing piles which are to be driven to rock or other point bearing material shall be designed for 9,000 psi, unless the Design Layout specifies otherwise. See the Piles Capacities Table.

**Pile Capacity**

1. AASHTO Group I thru VI Loads as applicable.

POINT BEARING PILE CAPACITIES				
Type (Steel)	A <sub>req</sub> (In. <sup>2</sup> )	Point Bearing		
		6,000 psi	9,000 psi	12,000 psi
HP10 x 42	12.35	37 Ton	56 Ton	74 Ton
HP12 x 53	15.58	47 Ton	70 Ton	94 Ton
HP14 x 73	21.46	65 Ton	97 Ton	129 Ton

FRICTION PILE CAPACITIES			
Type	Max. Capacity	Min. Capacity	Standard
CIP Conc. Pile (14")	30 Ton	20 Ton	MO Std. Plans Drawing 702.02
CIP Conc. Pile (20")	40 Ton	20 Ton	
CIP Conc. Pile (24")	48 Ton	30 Ton	

**2. Earthquake Loads**

Under Earthquake Loading conditions only, the ultimate capacities for steel point bearing piles is two times the value shown in the above table. For friction pile the ultimate capacity under earthquake loading is 1.5 times the values in the above tables.

Note: See Office Notes Section for the proper method for showing the design bearing values on the plans.

PILE DATA

Design

**Accuracy Required**

All capacities shall be taken to the nearest 1 (one) Ton. Loads shown on Plans shall not include overstress percentages for wind, temperature, etc.

**Maximum Specified Pile Lengths**

Steel Pile.....no limit  
CIP Conc. Pile.....no limit

**Test Pile**

Length shall be pile length specified plus 10 feet.

When test piles are specified to be Driven-In-Place they shall not be included in the number of piles indicated in the Pile Data Table.

**Load Test Pile**

When Load Test Pile are specified, the bearing value shall be determined by an actual load test in accordance with Missouri Std. Spec. 702.4.9.

**Steel Pile**

All steel in steel piling shall be ASTM A709 Grade 36 unless Earthquake Design requires ASTM A709 Grade 50 steel for bending stresses.

Note: For preboring for piles see Sections 702.4.3 and 702.6.6 of the Missouri Standard Specifications.

**PRECAST CONCRETE PILE**

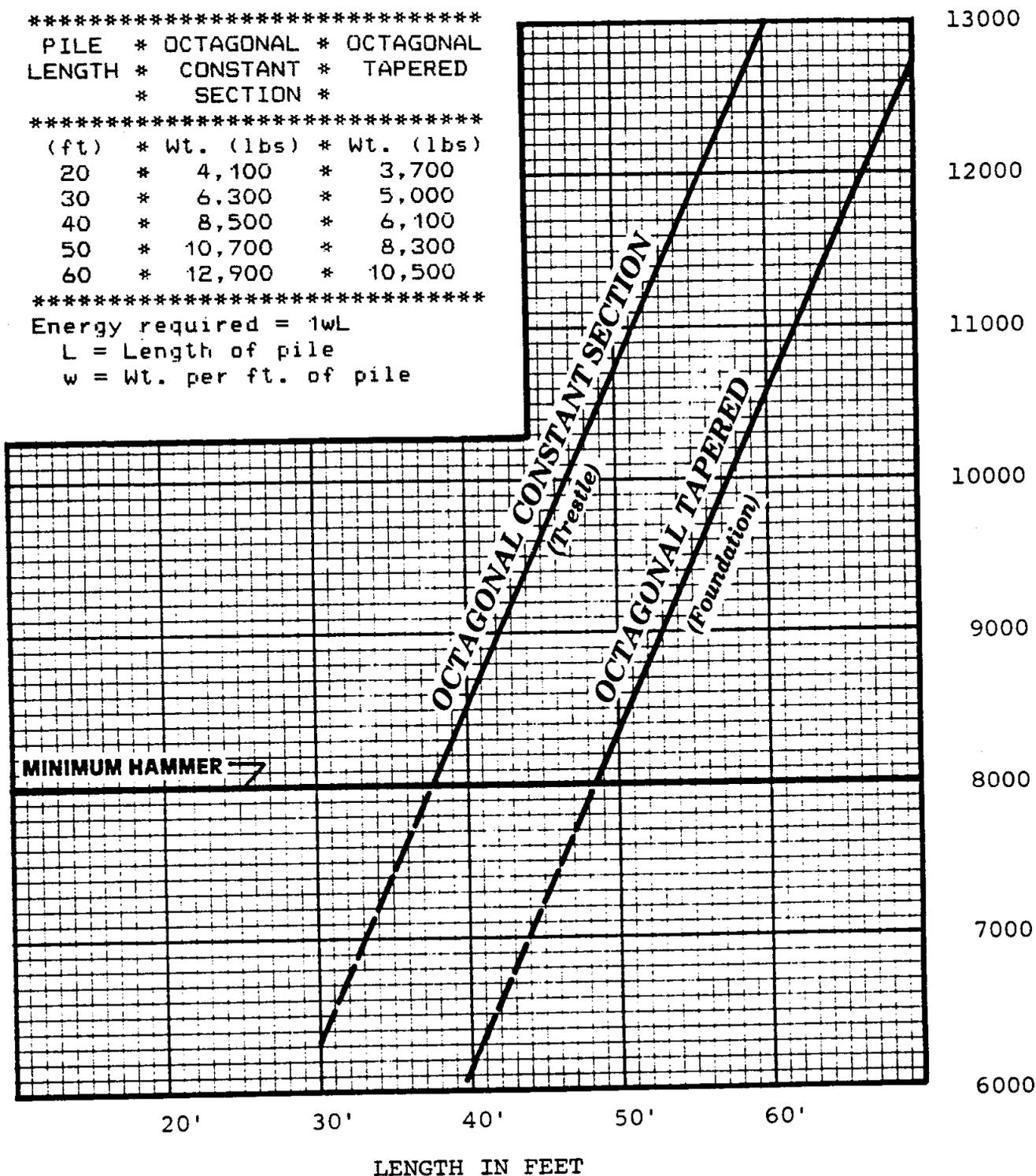
The details of precast concrete piles will be as indicated on Survey and Plans Drawing - 702.01. When precast piles are specified, the use of prestressed piles as an alternate will automatically be provided for by the pile standard.

Indicate hammer energy in "PILE DATA" table (nearest 100 ft-lbs) on the Design Plans.

Minimum hammer energy is 8,000 ft-lbs.

```

*****
PILE * OCTAGONAL * OCTAGONAL
LENGTH * CONSTANT * TAPERED
      * SECTION *
*****
(ft) * Wt. (lbs) * Wt. (lbs)
20 * 4,100 * 3,700
30 * 6,300 * 5,000
40 * 8,500 * 6,100
50 * 10,700 * 8,300
60 * 12,900 * 10,500
*****
Energy required = 1wL
L = Length of pile
w = Wt. per ft. of pile
    
```



HAMMER ENERGY - FT. LBS.

# DESIGN

## CAST-IN-PLACE CONCRETE PILE

### DETAILS - MISCELLANEOUS

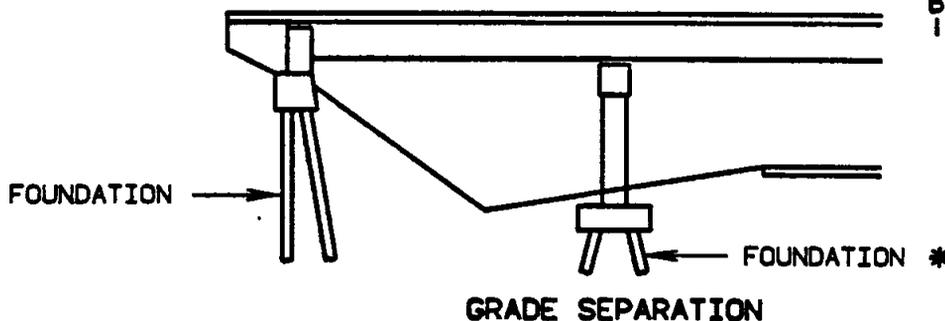
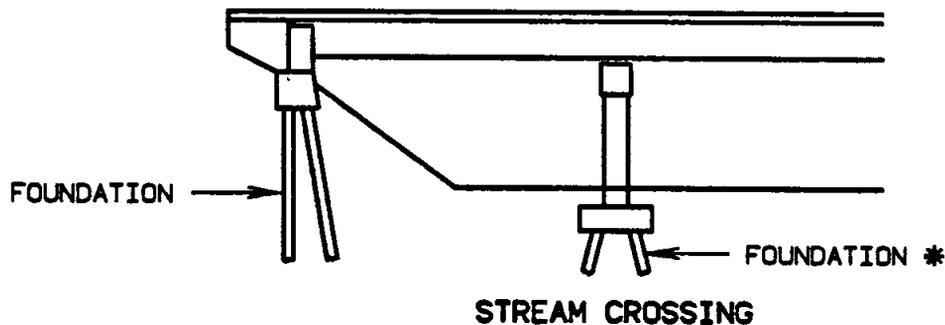
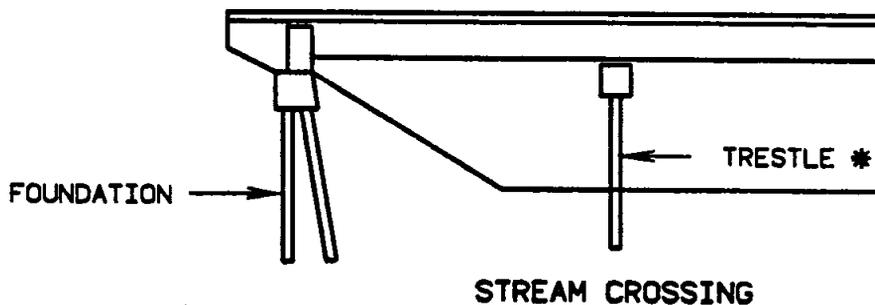
THE DETAILS OF CAST-IN-PLACE PILES WILL BE INDICATED ON SURVEYS AND PLANS STD. DRAWING 702.02, EXCEPT THAT THE SHELL AND LOCATION TYPE MUST BE INDICATED ON THE DESIGN PLANS AS SPECIFIED ON THE DESIGN LAYOUT.

THE KIND AND TYPE OF CAST-IN-PLACE PILES SHALL BE INDICATED IN THE "PILE DATA" TABLE ON THE DESIGN PLANS.

THE KIND OF PILE WILL BE SPECIFIED ON THE DESIGN LAYOUT.

THE TYPE OF PILE, TRESTLE OR FOUNDATION, MAY BE SELECTED FROM THE ILLUSTRATIONS SHOWN BELOW. WHEN THE ILLUSTRATIONS INDICATE THAT THERE WOULD BE BOTH TRESTLE AND FOUNDATION PILES ON THE SAME STRUCTURE, USE ALL PILES AS TRESTLE PILES THROUGHOUT THE STRUCTURE REGARDLESS OF THE TYPE OF BENT.

THE SHELL, THICK OR THIN, WILL NOT BE INDICATED IN THE "PILE DATA" TABLE UNLESS SPECIFIED ON THE DESIGN LAYOUT.



#### NOTE:

\* FOR SEISMIC CATEGORIES B, C & D SEE SHEETS NO. 1.2.4 1.2.5.

USE THICK SHELLS ONLY.

14" CAST-IN-PLACE CONCRETE PILE (NO MANDREL)  
TRESTLE OR FOUNDATION PILES

Design

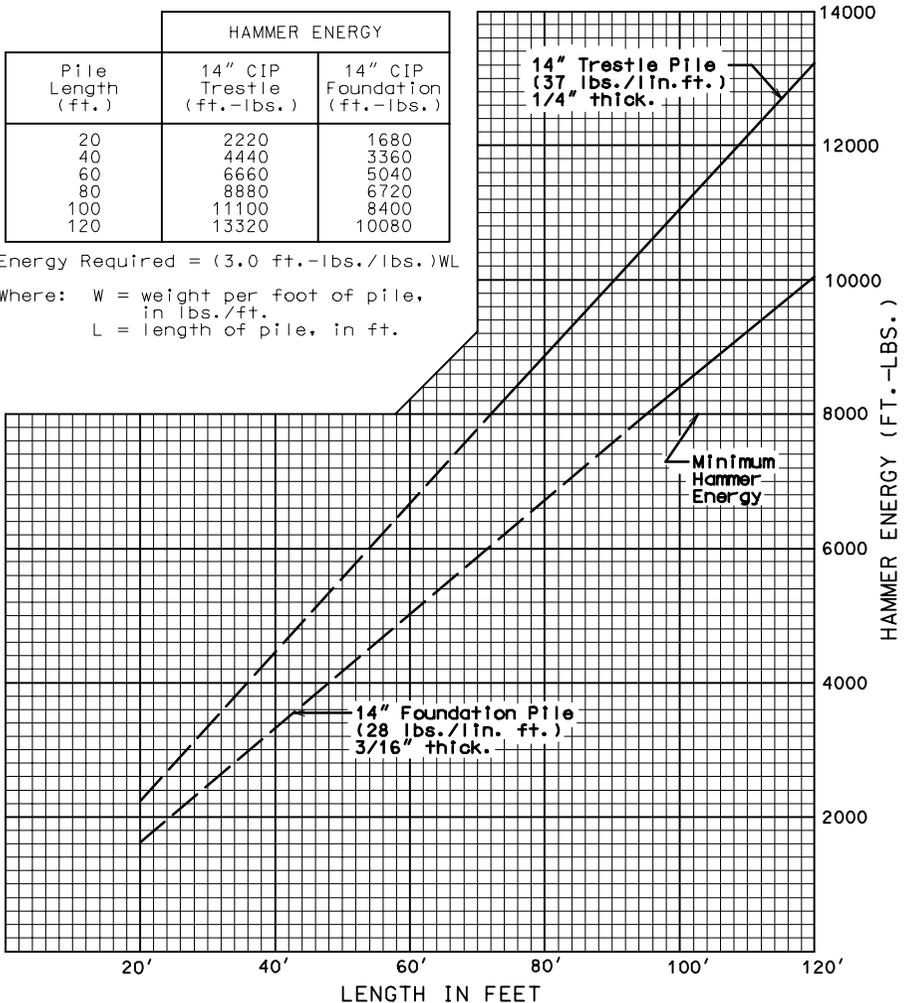
Indicate Hammer Energy in Pile Data Table (nearest 100 ft.-lbs.) on the Design Plans.

Minimum Hammer Energy is 8000 ft.-lbs.

Pile Length (ft.)	HAMMER ENERGY	
	14" CIP Trestle (ft.-lbs.)	14" CIP Foundation (ft.-lbs.)
20	2220	1680
40	4440	3360
60	6660	5040
80	8880	6720
100	11100	8400
120	13320	10080

Energy Required = (3.0 ft.-lbs./lbs.)WL

Where: W = weight per foot of pile, in lbs./ft.  
L = length of pile, in ft.



### 20" AND 24" CAST-IN-PLACE CONCRETE PILE (NO MANDREL) TRESTLE PILES

**Design**

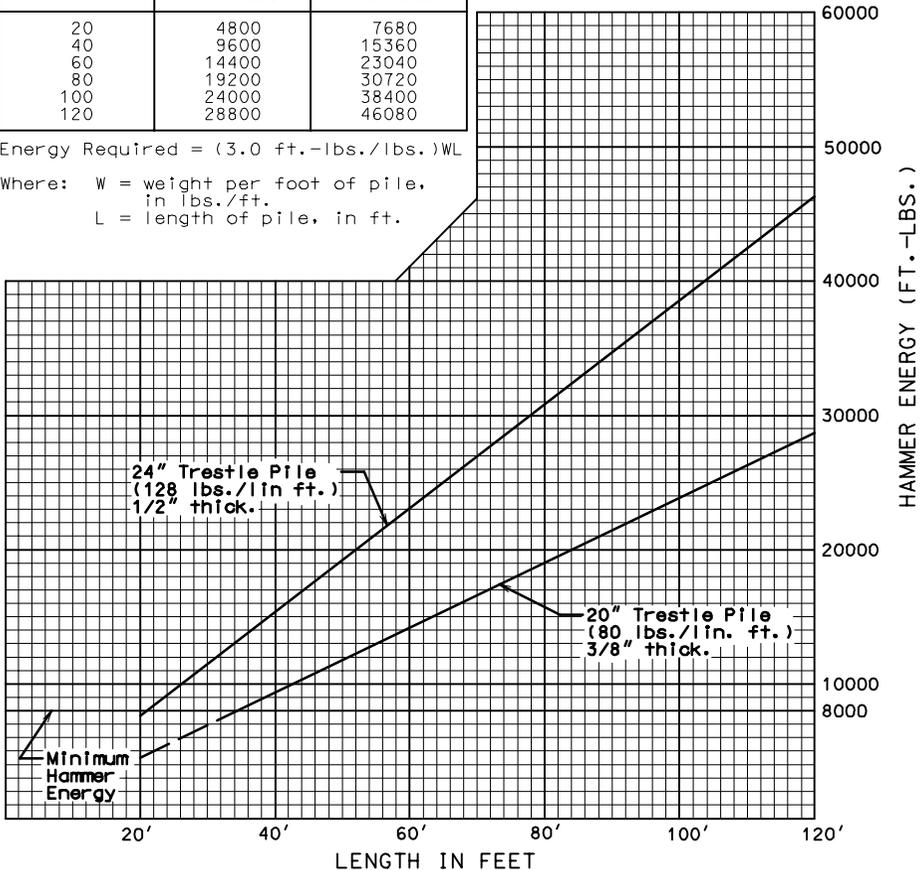
Indicate Hammer Energy in Pile Data Table (nearest 100 ft. lbs.) on the Design Plans.

Minimum Hammer Energy is 8000 ft.-lbs.

Pile Length (ft.)	HAMMER ENERGY	
	20" CIP Trestle Pile (ft.-lbs.)	24" CIP Trestle Pile (ft.-lbs.)
20	4800	7680
40	9600	15360
60	14400	23040
80	19200	30720
100	24000	38400
120	28800	46080

Energy Required = (3.0 ft.-lbs./lbs.)WL

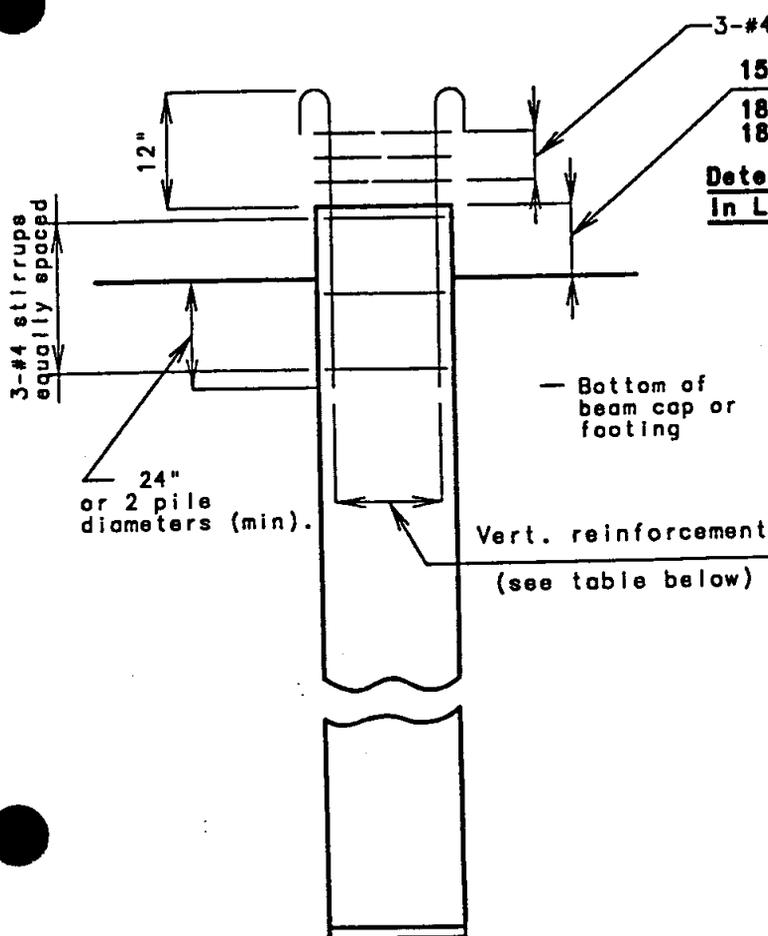
Where: W = weight per foot of pile, in lbs./ft.  
L = length of pile, in ft.



# DESIGN

## CAST-IN-PLACE CONCRETE PILE IN SEISMIC PERFORMANCE CATEGORIES B, C & D (\*)

14" CIP piles shall be used whenever possible.  
20" and 24" CIP piles may be used in categories C & D when necessary.



TYPICAL CAST-IN-PLACE PILE

3-#4 Stirrups • 3" cts.  
15" Pile Cap Intermediate Bent  
18" Pile Cap End Bent  
18" Pile Footing  
Determination of Seismic Moments in Piles  
in Liquefaction Area

CIP Concrete Piles in Footings

Determine Moment as  $M = P_R L_2 / 2$ .

CIP Concrete Pile Cap Intermediate Bents

Category B (Good Soil Only, see bridge manual section 1.2 Page 7.1.6)

Determine Longitudinal Moment as  $M = P_L L$ .

Determine Transverse Moment as  $M = P_T L_1 / 2$ .

Categories C & D

See Bridge Manual Section 1.2 page 7.5.7 for example of moment calculation in seismic categories C and D.

Definition of Variables

$P_L$  = Longitudinal lateral load per pile.

$P_T$  = Transverse lateral load per pile.

$P_R$  = Resultant of longitudinal & transverse lateral load per pile.

$L$  = Distance from point of fixity to top of beam cap.

$L_1$  = Distance from point of fixity to c of beam cap.

$L_2$  = Distance from point of fixity to bottom of footing.

$K$  = Effective length factor

Note: Use max.  $\frac{KL}{R} = 120$

Permissible Pile Size in Seismic Zones

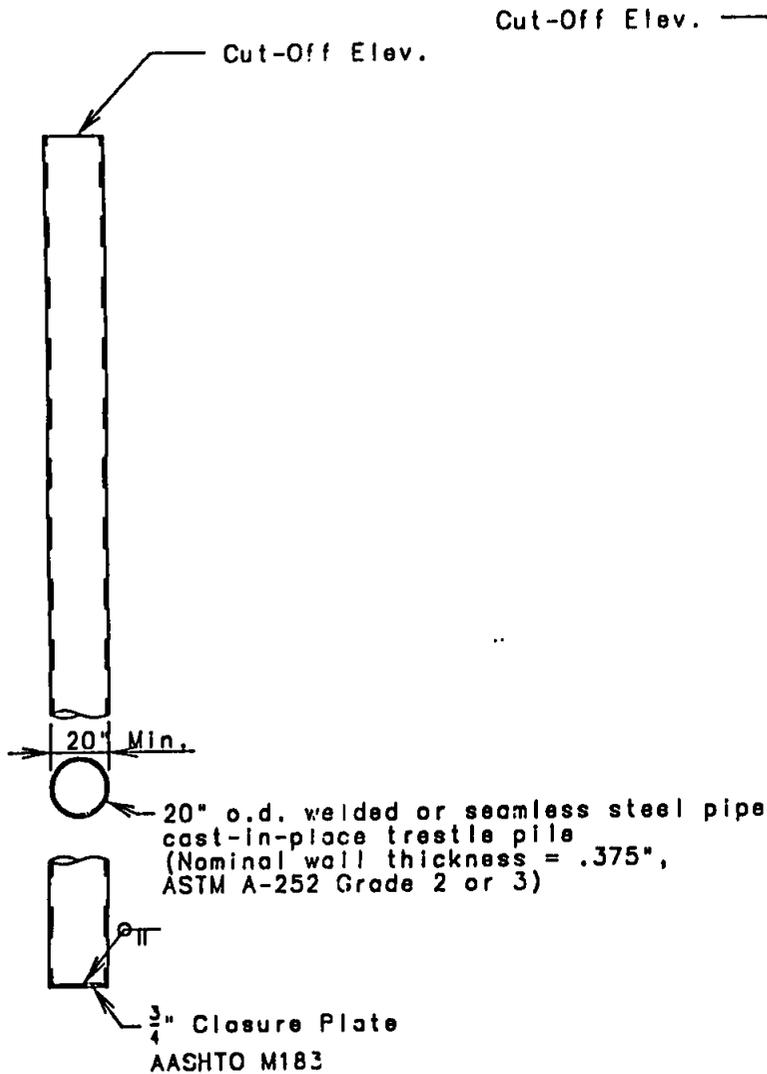
Pile Size (o.d.)	Nominal Thickness (in.)	Design Thickness (in.)	Vertical Reinforcement(**) (min.)
14"	.250	.156	6-#5's
20"	.375	.266	8-#6's
24"	.500	.375	12-#6's

Note: Design thickness is the nominal thickness less 12.5% for fabrication tolerance less 1/16" for corrosion. (A.A.S.H.T.O. 4.5.74, ASTM A-572)

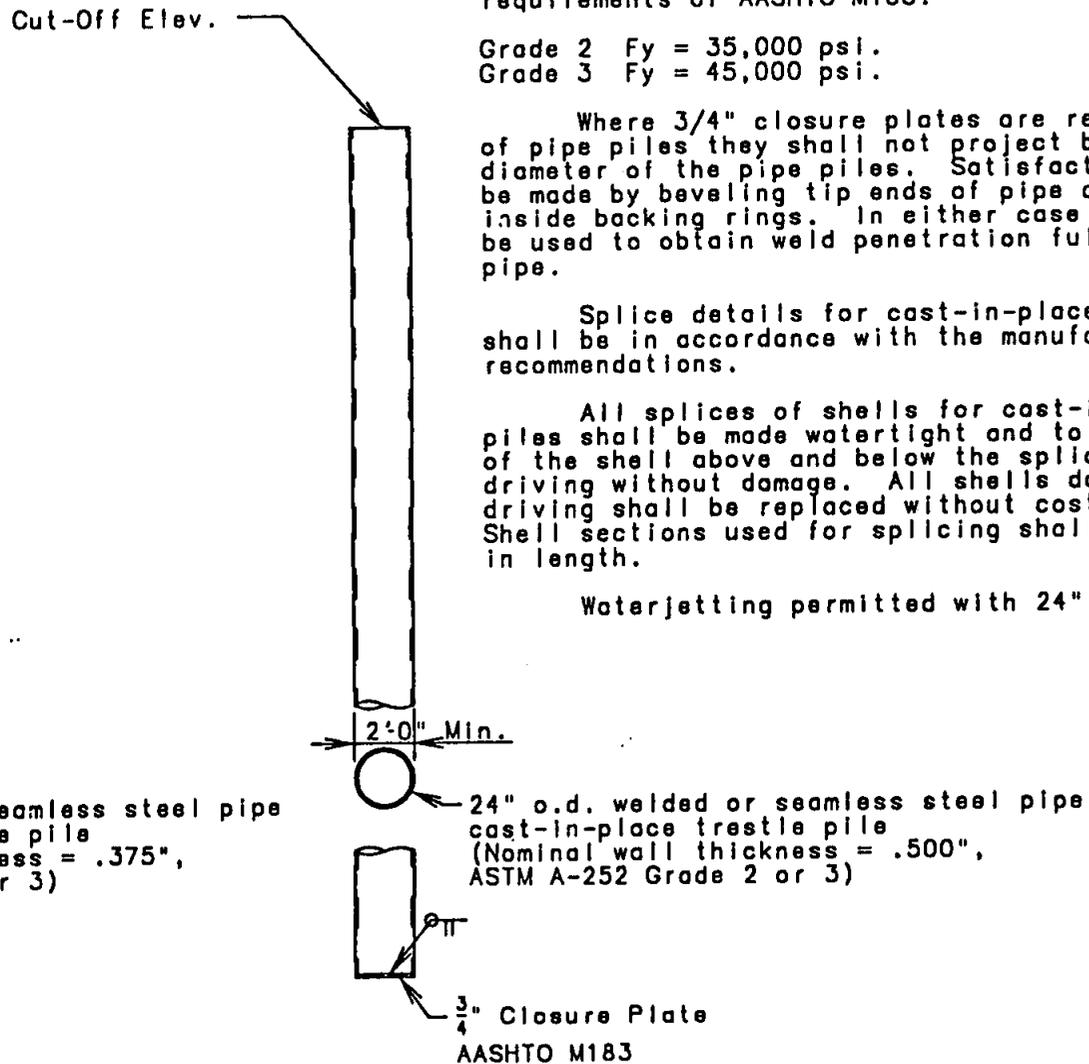
(\*\*) See A.A.S.H.T.O. Standard Specification for Seismic Design of Highway Bridges 6.4 and 6.3.1 (c).

Note: Specify trestle type only and check induced seismic moment at point of fixity.

(\*) Friction piles in seismic performance categories B, C & D shall be cast-in-place steel pipe pile only.



WELDED OR SEAMLESS STEEL PIPE  
IN-PLACE PILE



WELDED OR SEAMLESS STEEL PIPE  
CAST-IN-PLACE PILE

Note: All concrete for cast-in-place piles shall be Class B1.

Welded or seamless steel pipes shall meet the requirements of A.S.T.M. specification A-252, Grade 2 or 3, and the 3/4" closure plates shall meet the requirements of AASHTO M183.

Grade 2  $F_y = 35,000$  psi.  
Grade 3  $F_y = 45,000$  psi.

Where 3/4" closure plates are required for tips of pipe piles they shall not project beyond the outside diameter of the pipe piles. Satisfactory weldments may be made by beveling tip ends of pipe or by use of inside backing rings. In either case proper gaps shall be used to obtain weld penetration full thickness of pipe.

Splice details for cast-in-place concrete piles shall be in accordance with the manufacturers recommendations.

All splices of shells for cast-in-place concrete piles shall be made watertight and to the full strength of the shell above and below the splice to permit hard driving without damage. All shells damaged during driving shall be replaced without cost to the State. Shell sections used for splicing shall be at least 5'-0" in length.

Waterjetting permitted with 24" or 20" piles.

DETAILS

**STRUCTURAL STEEL PILES**

**Design**

**Size**

Steel bearing piles of the following sections may be used:

Section	Area
HP 10 x 42	12.35 sq. in.
HP 12 x 53	15.58 sq. in.
HP 14 x 73	21.46 sq. in.

The HP 10 x 42 Section should generally be used unless a heavier section produces a more economical design. For an economic comparison, use a price of \$27.00 per lineal foot for 10" piles, \$30.00 per lineal foot for 12" piles or \$35.00 per lineal foot for 14" piles. The same size pile must be used for all footings on the same bent. Pile size may vary from bent to bent.

**Capacity**

The pile indicated shall be designed for 9,000 psi point bearing, unless the Design Layout specifies otherwise. When a very large number of heavily loaded piles is required, the use of 12,000 psi point bearing with a pile loading test may be indicated. Consult the Structural Projector Manager.

**Pile Tips**

Pile tip reinforcement shall be used if specified on the Design Layout.

**Hammer Energy**

In calculating the minimum energy developed by hammer per blow, use the largest of the following:

- (1) 3.0 ft.-lbs./lbs. times total weight of the pile in pounds, see page 1.3-2 Hammer Energy Based on Pile Length.
- (2) 225 ft.-lbs./ton times the pile bearing value in tons, see page 1.3-3 Hammer Energy Based on Design Bearing.
- (3) 7,000 ft.-lbs.

If the required batter differs from that indicated, (2" per 12") and (3' per 12"), on the chart, see the Missouri Standard Specifications.

"Hammer Energy Required" shall not be given on Plans above a maximum value of 24,000 ft.-lbs.

Whenever the piling situation results in a value over a preferable maximum of 22,000 ft.-lbs., a redesign shall be made for a greater number of piles so as to hold the value to around 22,000 ft.-lbs. A value of 24,000 ft.-lbs. will be permitted for only very special situations where numbers of piles are limited by construction clearances or other circumstances.

STRUCTURAL STEEL PILES  
HAMMER ENERGY BASED ON PILE LENGTH

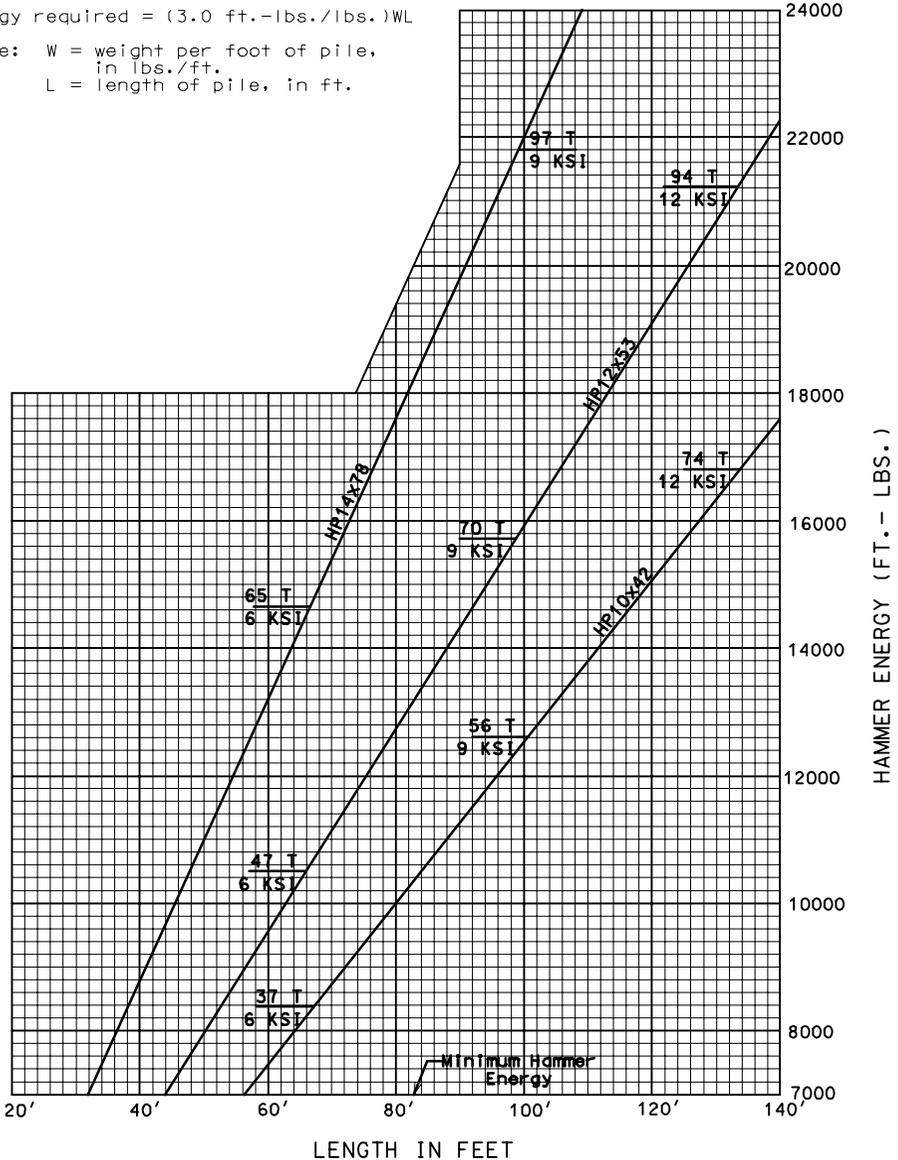
Design

Indicate hammer energy in Pile Data Table (nearest 100 ft.-lbs.) on the Design Plans.

Minimum hammer energy is 7,000 ft.-lbs.

Energy required = (3.0 ft.-lbs./lbs.)WL

Where: W = weight per foot of pile,  
in lbs./ft.  
L = length of pile, in ft.



**STEEL BEARING PILE**

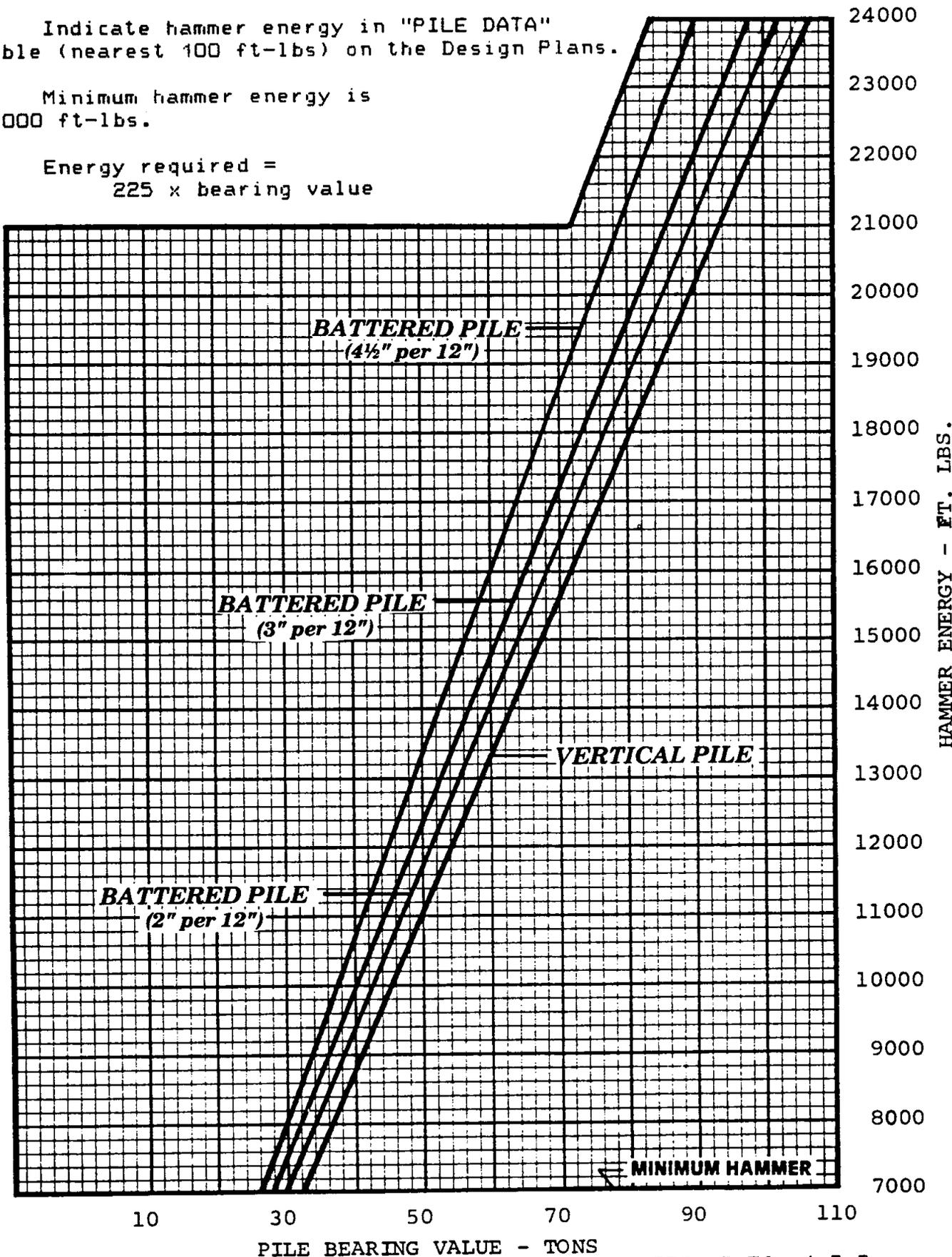
(Hammer energy based on "Design Bearing".)

(See Missouri Standard Specifications - 702.4.10.)

Indicate hammer energy in "PILE DATA" table (nearest 100 ft-lbs) on the Design Plans.

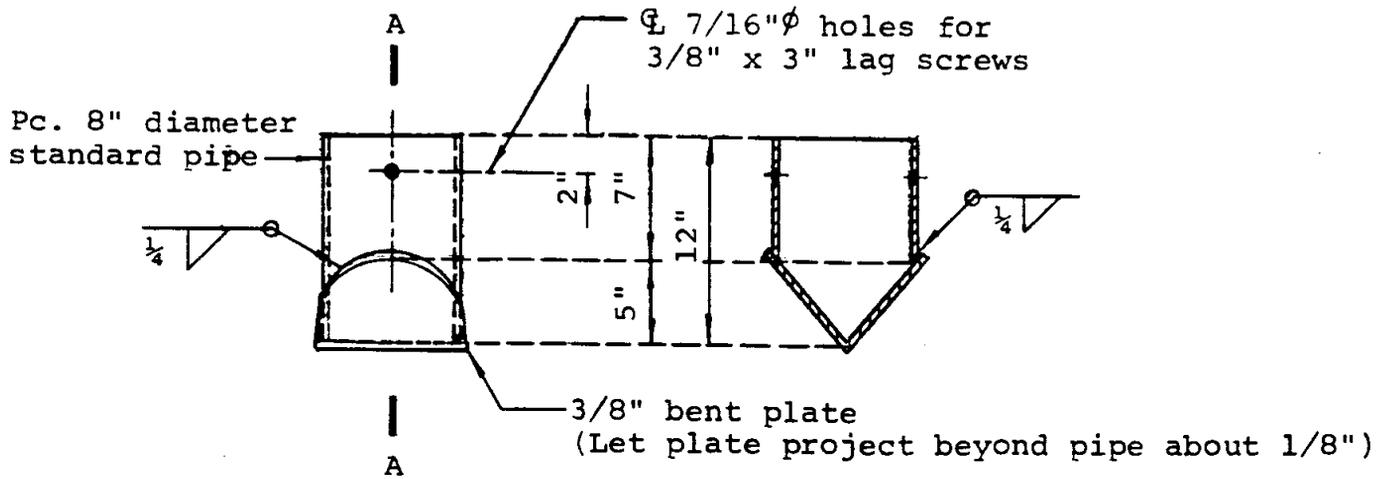
Minimum hammer energy is 7,000 ft-lbs.

Energy required =  
225 x bearing value



DETAILS

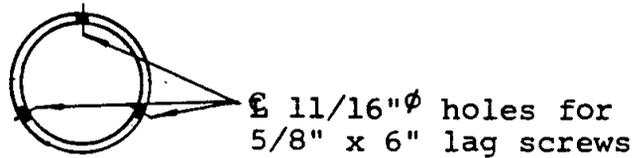
TIMBER PILES



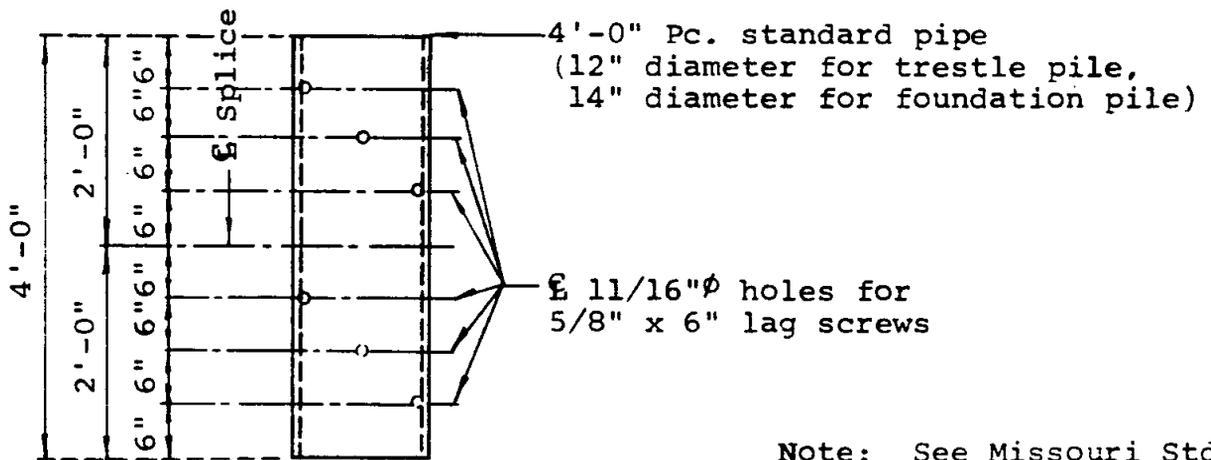
Note: See Missouri  
Std. Spec. 702.2.6  
and 1050.7

SECTION A-A

DETAILS OF PILE SHOE



PLAN



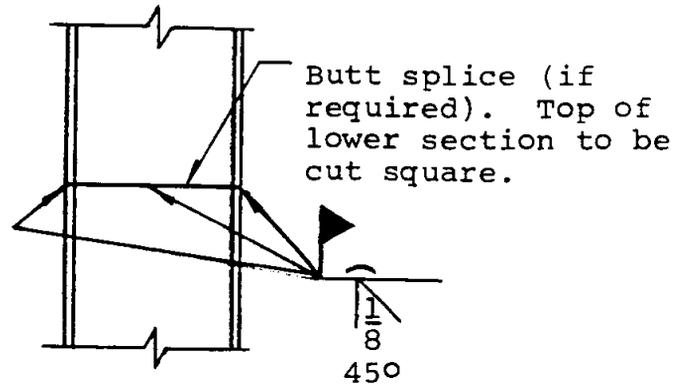
Note: See Missouri Std.  
Spec. 702.4.5.3

ELEVATION

DETAILS OF PILE SPLICE

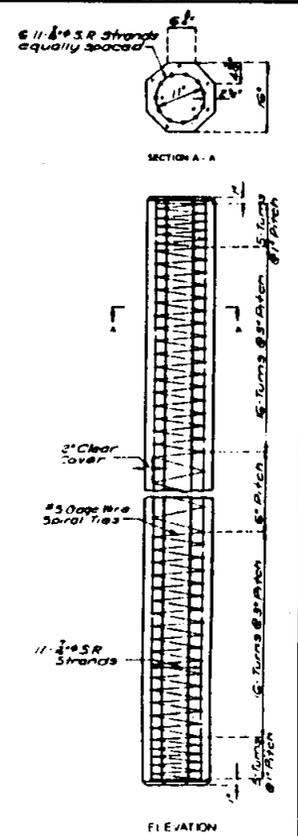
DETAILS

STEEL PILES



DETAIL OF STEEL PILE SPLICE



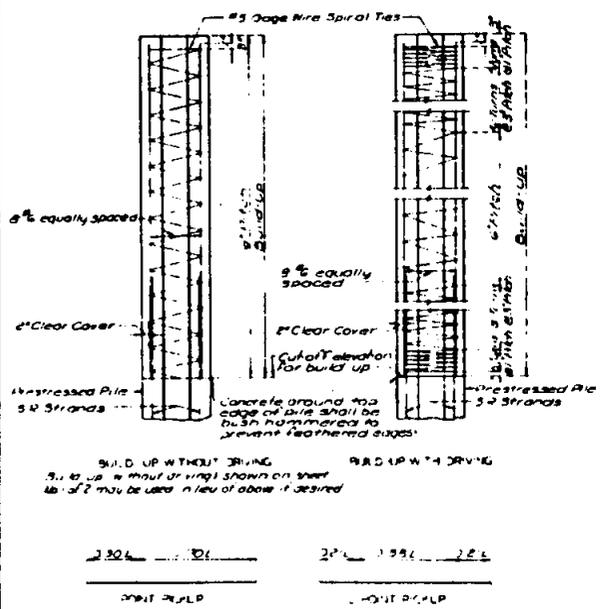
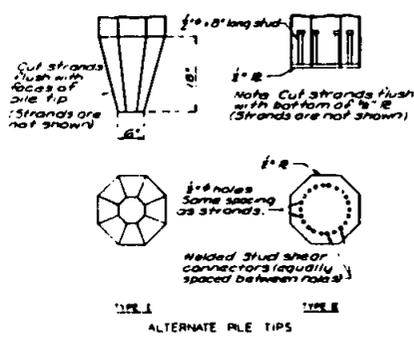


**ALTERNATE PILE HEADS:**  
Method of attachment of a pile to build-up may be by any of the following methods:

1. Allow all strands to project a minimum of 2'-0" or cut off at least 2'-0" of pile and splice a minimum of 2'-0" of strands.
2. Cast 8 bars (equally spaced) into pile head. Use #6 bars for build-up without driving and #8 bars for build-up with driving. All bars shall extend into pile head and project from pile head a minimum of 32 diameters.
3. Drill 8 holes in pile head (equally spaced) for installation of 8 grouted dowel bars of same size and length as in 2.
4. Provide cored holes for bars as in 3.

If build-up under any alternate is required on treated pile it shall be located so as to extend at least 18" below finished ground line.

No bars or strands are to extend from head of pile or build-up into footing or pile cap.



**GENERAL NOTES:**

1. All concrete shall be Class A1 with 40-dominant aggregate having a design strength of 3,000 psi in compression at 28 days.
2. Prestressing reinforcement shall consist of eleven #7 seven-wire stress relieved strands conforming to the requirements of ASTM A285, Grade 270. Total initial tension in strands before release shall be 207,900 pounds.
3. Spiral reinforcement shall be plain reinforcing bars or cold drawn wire. Reinforcement for build-ups other than the bars shall meet requirements of Standard Specifications.
4. Structural steel for pile tips shall be structural carbon steel ASTM A36 or other approved steel.
5. Strands shall be de-tensioned one at a time, keeping strands in tension as nearly as practicable, symmetrically about the axis of a pile.
6. Piles may be removed from the bed at any time after stress transfer.
7. Sections of prestressed concrete piles shall not be spliced together.
8. Build-ups may be used as follows: where no additional driving is required, either of the build-ups (without driving) shown on sheets 1 or 2 may be used; if additional driving is required, the build-up (with driving) shown on sheet 2 shall be used.

MISSOURI HIGHWAY AND TRANSPORTATION COMMISSION

**16" CONCRETE PILES**  
(APPROVED PRESTRESSED TYPES)

REVISION AUGUST 1981

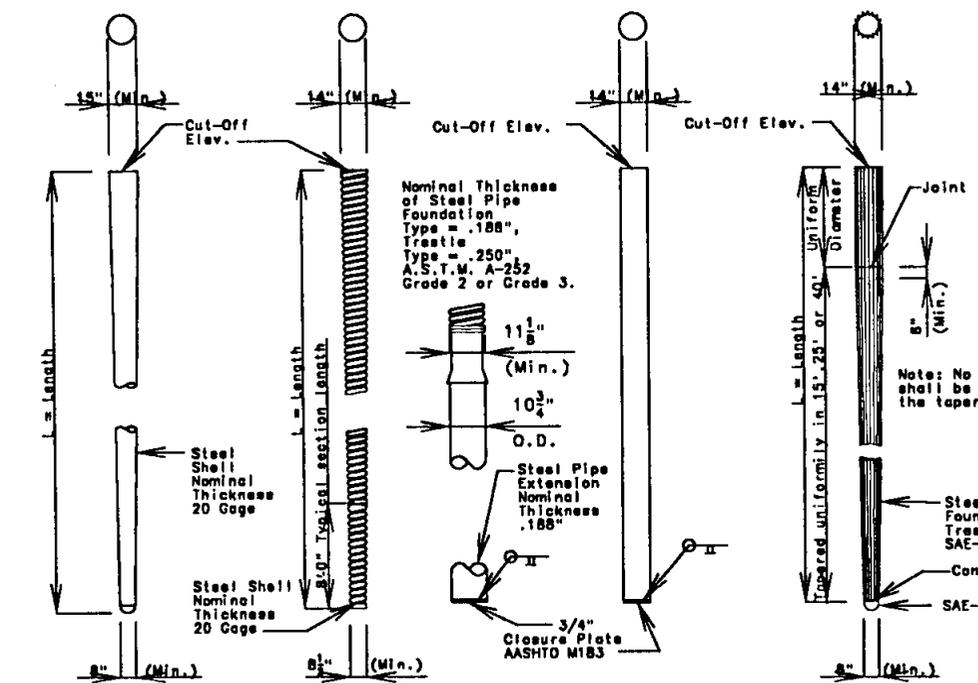
DRAWING 702.01  
SHEET 2 of 2

CONVERSION FACTORS FOR EQUIVALENTS			
1 in.	25.4 mm	1 ft.	0.3048 m
1 lb.	4.448 N	1 yd.	0.9144 m
1 cu ft.	0.02832 m <sup>3</sup>	1 cu yd.	0.76456 m <sup>3</sup>
1 sq ft.	0.09290 m <sup>2</sup>	1 sq yd.	0.83613 m <sup>2</sup>
1 cu in.	0.0001639 m <sup>3</sup>	1 cu ft.	0.02832 m <sup>3</sup>
1 sq in.	0.0006452 m <sup>2</sup>	1 sq ft.	0.09290 m <sup>2</sup>
1 cu ft.	0.02832 m <sup>3</sup>	1 cu yd.	0.76456 m <sup>3</sup>
1 sq ft.	0.09290 m <sup>2</sup>	1 sq yd.	0.83613 m <sup>2</sup>

# ROADWAY DESIGN STANDARD DRAWINGS

CAST-IN-PLACE  
CONCRETE PILES  
(702.02)

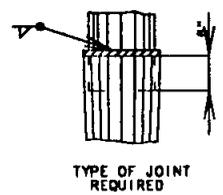
**GENERAL NOTES:**  
 All concrete for Cast-in-Place piles shall be Class B1.  
 Thin shelled types, driven with cores or mandrels, shall have a nominal thickness of 20 GA. and shall, in every case, have such additional thickness as may be required to provide sufficient strength to withstand driving without injury and to resist harmful distortion or buckling due to soil pressure after being driven and the mandrel removed.  
 Thick shelled types, driven without cores or mandrels, welded or seamless steel pipes, shall meet the requirements of A.S.T.M. specification A-252, Grade 2 or Grade 3, and the 3/4" closure plates shall meet the requirements of AASHTO M183.  
 Thick shelled types, driven without cores or mandrels, fluted pipes, shall meet the requirements of specification SAE-1010 or SAE-1015 and the forged steel tips or noses shall meet the requirements of SAE-1020.  
 The minimum wall thickness of any spot or local area of any type shell shall not be more than 12.5% under the specified nominal thickness.  
 Where 3/4" closure plates are required for tips of pipes they shall not project beyond the outside diameter of the pipe piles. Satisfactory weldments may be made by beveling tip ends of pipe or by use of inside backing rings. In either case proper gaps shall be used to obtain weld penetration full thickness of pipe.  
 Splice details for cast-in-place concrete piles shall be in accordance with the manufacturers recommendations.  
 All splices of shells for cast-in-place concrete piles shall be made watertight and to the full strength of the shell above and below the splice to permit hard driving without damage. All shells damaged during driving shall be replaced without cost to the state. Shell sections used for splicing shall be at least 5'-0" in length. The splice at top of tapered section shall be at least 3'-0" below stream bed for intermediate trestle type bents.



THIN UNIFORM TAPERED CAST-IN-PLACE PILE (Foundations only)  
 THIN STEP-TAPERED OR UNIFORM DIAMETER CAST-IN-PLACE (Foundations only)  
 WELDED OR SEAMLESS STEEL PIPE CAST-IN-PLACE (Foundations or Trestles as specified)  
 FLUTED TYPES CAST-IN-PLACE PILE (Foundations or Trestles as specified)

THIN SHELLED TYPES  
(DRIVEN WITH CORES OR MANDRELS)

THICK SHELLED TYPES  
(DRIVEN WITHOUT CORES OR MANDRELS)



MISSOURI HIGHWAY AND TRANSPORTATION COMMISSION	
CAST-IN-PLACE CONCRETE PILES (APPROVED TYPE)	
REVISED: MAY 1993	DRAWING 702.02C SHEET 1 OF 1

REVISED: MAY 1993

SEC. 3.74 3.1.3